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Francesco Feri
Bernd Irlenbusch
Matthias Sutter

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Francesco Feri
University of Innsbruck

Bernd Irlenbusch
London School of Economics and IZA

Matthias Sutter
University of Innsbruck, University of Gothenburg and IZA

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IZA

P.O. Box 7240
53072 Bonn
Germany

Phone: +49-228-3894-0
Fax: +49-228-3894-180
E-mail: iza@iza.org

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ABSTRACT

Efficiency Gains from Team-Based Coordination: Large-Scale Experimental Evidence*

The need for efficient coordination is ubiquitous in organizations and industries. The literature on the determinants of efficient coordination has focused on individual decision-making so far. In reality, however, teams often have to coordinate with other teams. We present an experiment with 825 participants, using six different coordination games, where either individuals or teams interact with each other. We find that teams coordinate much more efficiently than individuals. This finding adds one important cornerstone to the recent literature on the conditions for successful coordination. We explain the differences between individuals and teams using the experience weighted attraction learning model.

JEL Classification: C71, C91, C92

Keywords: coordination games, individual decision-making, team decision-making, experience-weighted attraction learning, experiment

Corresponding author:

Matthias Sutter
University of Innsbruck
Department of Public Finance
Universitaetsstrasse 15
A-6020 Innsbruck
Austria
E-mail: matthias.sutter@uibk.ac.at

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1. Introduction

Coordination problems prevail in a large variety of contexts, such as organizational design, technology adoption and diffusion, monopolistic competition, speculative attacks on currency markets, or bank runs, to name just a few (see, e.g., Thomas C. Schelling, 1980, James W. Friedman, 1994, Colin F. Camerer and Marc J. Knez, 1997, or Russell Cooper, 1999, for more examples). Due to the ubiquity of coordination problems and the eminent importance of successful coordination for the functioning of firms, organizations, or industries, there is a large body of research in economics on coordination games with multiple, often Pareto-ranked, pure strategy equilibria.[1] The equilibrium selection problems in these games resemble informal, decentralized coordination in situations which are hard to govern by explicit contracts. Since the determinants for coordination failure or success can more easily be controlled for and identified in laboratory studies than in field studies, most of the work on coordination has relied on controlled experiments, starting with the seminal papers by John B. van Huyck, Richard C. Battalio and Richard O. Beil (1990, 1991) and Russell Cooper et al. (1990, 1992). Strikingly, though, when examining the determinants of coordination failure or success, all experimental studies have exclusively focused on individual decision-making so far.

In reality, however, teams often have to coordinate with other teams. In their classic book *The Wisdom of Teams*, Jon R. Katzenbach and Douglas K. Smith (1993) emphasize that the "team is the basic unit of performance for most organizations" (p. 27). Knez and Duncan Simester (2001) present a very illuminating field study of the importance of team decision-making in coordination game. They have studied the influence of incentive systems on the success of coordination at Continental Airlines. In particular, this airline offered a firm-wide bonus to all employees if specific on-time arrival and departure performance goals were met.

[1] Coordination games have not only captured so much interest because they resemble many relevant real-world situations, but also because they are interesting from a genuine game-theoretical perspective, as they address the non-trivial issue of equilibrium selection (John Harsanyi and Reinhard Selten, 1988).

This required the efficient coordination of several work teams on the ground (at the starting and landing airport) and in the air. Hence, Knez and Simester's (2001) case study serves as a prime example for coordination among teams. They were not interested in whether coordination among teams was more or less successful than coordination among individuals, though. In fact, except for two very recent papers by Gary Charness and Matthew O. Jackson (2007, 2008), the literature has not yet addressed the comparative performance of individuals and teams in coordination games. Charness and Jackson (2007, 2008) have examined a Stag Hunt-game, which is a two-player coordination game. Two persons formed one group (i.e., one player). There was no interaction within a group other than each member deciding individually for one of the two strategies (Stag or Hare). In different treatments they varied the rule how the two decisions were aggregated to the group's decision. Comparing the results across treatments shows that group play can be more or less efficient than individual play (where only two subjects play the two-person Stag Hunt game). If it is sufficient that one group member chooses the more efficient strategy (Stag) to implement that as the group decision, then group play is more efficient than individual play. If both group members have to choose Stag to implement it as the group decision, individual play is more efficient.

In this paper, we present a large-scale experimental study with 825 participants in order to examine whether individual or team decision-making has any influence on coordination failure or success. Our approach differs from Charness and Jackson (2007, 2008) in the following ways: (i) We set up teams of three members each. Team members can communicate with each other before making a decision, as this opportunity seems to characterize team decision-making in many contexts. (ii) We let five – instead of only two – parties interact with each other. Since an increase in the number of interacting parties has been found to make efficient coordination more difficult (Roberto A. Weber, 2006), it seems warranted to examine coordination behavior of individuals and teams under such more demanding conditions. (iii) We study six different coordination games – two weakest-link games and four average-opinion games – in order to check the robustness of our results. Our results show that teams are persistently and remarkably better at coordinating efficient outcomes than individuals are. Therefore, our study adds an important cornerstone to the recent literature on the determinants[2] of successful and efficient coordination.

The seminal contributions on experimental coordination games (van Huyck et al., 1990, 1991; Cooper et al., 1990, 1992) left many researchers with the impression that coordination failure is a common phenomenon (Chip Heath and Nancy Staudenmayer, 2000; Camerer, 2003). Coordination failure was, and is, understood as a group of subjects either failing to coordinate on one of the multiple equilibria of Pareto-ranked coordination games (denoted as "miscoordination" in the following) or coordinating on a Pareto-dominated, i.e., inefficient, equilibrium due to subjects' strategic uncertainty about the other subjects' choices.[3]

Subsequent research has identified many factors that facilitate efficient coordination, with many of these factors typically applying in firms and organizations. In our discussion we focus here on financial incentives, communication, and group size.[4] Financial incentives – which make the payoff-dominant equilibrium more attractive in relation to the risk-dominant one – have been shown to increase the efficiency of coordination. This means that if the attractiveness of more efficient equilibria is reinforced through additional payments (Brandts and Cooper, 2006a, 2006b; John Hamman, Scott Rick and Weber, 2007)[5] or through a

[2] Note that the excellent survey on behavior in coordination games by Giovanna Devetag and Andreas Ortmann (2007) does not mention teams as a possible factor.

[3] See Vincent P. Crawford (1991, 1995) for theoretical treatments of behavior in coordination games and how strategic uncertainty can affect the adaptive behavior of subjects in these games.

[4] The survey by Devetag and Ortmann (2007) also discusses other factors, like intergroup competition (Gary Bornstein, Uri Gneezy and Rosemarie Nagel, 2002), number of repetitions (Siegfried Berninghaus and Karl-Martin Ehrhart, 1998), feedback effects (Devetag, 2003, Jordi Brandts and David J. Cooper, 2006b), or matching effects (David Schmidt et al., 2003). A recent paper by Crawford, Gneezy and Yuval Rottenstreich (2008) shows that salient labels may also promote more efficient coordination, but only as long as payoffs are symmetric. Even minutely asymmetric payoffs yield a very large degree of miscoordination in their two-person coordination games.

[5] Brandts and Cooper (2006a) and Hamman et al. (2007) agree on the effectiveness of financial incentives, but report different results with respect to the persistence of positive effects of financial incentives after they have been removed again. In Brandts and Cooper (2006a) coordination remains efficient even after the increased financial incentives have been abolished again, whereas in Hamman et al. (2007) coordination deteriorates when bonuses are removed. Hamman et al. (2007) explain the different findings by the different design of financial incentives. Whereas in Hamman et al. (2007) bonuses are only paid when the most efficient equilibria are

decrease in the effort costs for more efficient equilibria (Jacob Goeree and Charles A. Holt, 2005), then one can regularly observe more efficient coordination.

Communication is another important factor that can prevent coordination failure. The efficiency-increasing effect of pre-play cheap-talk communication – already documented in Cooper et al. (1992) – has been strongly confirmed in more recent studies on two-person coordination games (see, e.g., Charness, 2000, or John Duffy and Nick Feltovich, 2002, 2006). However, Andreas Blume and Ortmann (2007) – using the experimental designs of van Huyck et al. (1990, 1991) – have shown for the first time that costless cheap-talk through signaling one's intended action can yield efficient coordination even in large groups (of nine individuals).[6]

Group size is another crucial factor for efficient coordination. Starting with van Huyck et al. (1990, 1991), the general evidence is that larger groups are less likely to coordinate on an efficient equilibrium (absent communication; see Blume and Ortmann, 2007). Table 2 in Weber (2006) provides a nice overview on several coordination experiments with different group sizes, showing that coordination gets less efficient with a larger group size. In his own study, however, Weber (2006) demonstrates how the negative effects of group size on the likelihood of efficient coordination can be avoided. Knowing that coordination is typically successful in very small groups, Weber (2006) sets up groups of two subjects each in the beginning and lets them grow by adding individuals step by step until the group includes 12 subjects. When new entrants know the history of coordination in the group up to the moment of entering, then the more efficient coordination of a small group can be sustained also when it grows into a larger group. Weber (2006) then continues to argue that achieving efficient

reached, the financial incentives in Brandts and Cooper (2006a) apply to all but the least-efficient equilibrium. The latter makes it easier for groups to "climb up" to more efficient coordination.

[6] There are several experiments that can be interpreted as implying the use of costly communication (which then serves as a signaling device; see Crawford and Bruno Broseta, 1998). Van Huyck et al. (1993) have shown that adding a pre-play auction for the right to participate in a coordination game increases the efficiency of coordination, because the existence of a market price for playing the game serves as a coordination device in the equilibrium selection problem. Similar results have been presented by Gerard P. Cachon and Camerer (1996) and

coordination by managing growth may be one reason why firms and organizations that start out small may be successful in sustaining efficient coordination when they grow larger.

In this paper, we test a related hypothesis, i.e., that firms and organizations may be successful at sustaining efficient coordination by setting up teams that coordinate internally at first, but then coordinate across teams. For instance, when launching a new product, several teams in a company (like the marketing, the R&D, or the accounting team) may have to coordinate their actions on the best way to proceed. By grouping individuals into teams (or divisions), a company can also reduce the number of players involved in coordination. Thus, the organizational feature of team decision-making may be seen as an attempt to facilitate efficient coordination in large companies. The recent emergence of network organizations also suggests that organizational structures relying on coordination among teams exhibit decisive advantages (for an overview, see Steve Cropper et al., 2008). To shed light on the validity of this conjecture, we run six different coordination game experiments with either teams of three subjects each or individuals as decision makers. Two games are weakest-link games (also widely known as minimum games), and four games are average-opinion games (also called median games in the literature).

Our results show that teams are clearly better at avoiding miscoordination and coordinating an efficient equilibrium. Across all six games, teams earn on average about 20% more per capita than individuals. We explain the different behavior of individuals and teams by applying the experience weighted attraction learning model of Camerer and Teck-Hua Ho (1999). Teams are found in all games to be more attracted by payoff-dominant choices. Hence, their choices are guided much more by the opportunities for higher payoffs in more efficient equilibria, meaning that teams are more sensitive to payoffs, both those realized as well as hypothetical ones from strategies that were not chosen.

Ondrej Rydval and Ortmann (2005), who show that subjects' loss avoidance makes coordination more efficient when there is a price to be paid for participation in a coordination game.

The rest of the paper is organized as follows. Section 2 presents the coordination games that will be used in our experiments. Section 3 introduces the experimental design. Section 4 reports the experimental results, and section 5 uses the experience weighted attraction learning model to explain the differences between individuals and teams. Section 6 relates our findings to the literature on team decision-making. Section 7 concludes the paper.

2. The coordination games

We have chosen two different types of coordination games for our study: weakest-link games and average-opinion games. Both types of games belong to the class of order-statistic games, with the minimum or the median of actions as the relevant order statistic.

In weakest-link games, payoffs depend on the minimum number[7] chosen within a group, hence the connotation with the weakest link in a chain. In fact, the overall productivity of an organization often depends on the individual or unit doing the worst job. Think, for instance, of delays in air transport if the ground crew for fuelling is late.

In average-opinion games, a decision maker's payoff is increasing in the median number chosen in his group, but decreasing in the absolute difference between the own number and the group's median.[8] Financial investments on stock markets provide a prime example for an average opinion game, as the most profitable action to take depends on the other investors' (median) choices. Currency attacks may also be interpreted as an average-opinion game (see, e.g., Friedrich Heinemann, Nagel and Peter Ockenfels, 2004).

[7] These "numbers" are also referred to as values, efforts, investments, or actions, in the literature. In general, the interpretation is that higher "numbers" imply higher personal costs, but nevertheless pay off when all other group members also choose higher "numbers".

[8] For one of our average opinion games (SEPARATRIX, see below) the structure is slightly different.

2.1. The two weakest-link games in detail

The first weakest-link game (denoted *WL-BASE* henceforth, see panel [A] of Table 1) is taken from van Huyck et al. (1990). There are seven numbers to choose from. Payoffs increase in the minimum number chosen in the group, but decrease in the own number for a given minimum. Thus, the best response to a given strategy combination of the other players is to match the action of the "weakest link", i.e., of the other player who has chosen the lowest number. *WL-BASE* has seven pure-strategy, Pareto-ranked equilibria along the diagonal. Using the concept of payoff-dominance (Harsanyi and Selten, 1988) as an equilibrium selection device would lead to the choice of the only equilibrium that is not strictly Pareto-dominated by any other equilibrium, hence to the equilibrium with the highest number. Applying the maximin-criterion, though, would induce players to choose the lowest number, since this choice guarantees the largest payoff in the worst possible case. Choosing such a "secure" action yields the least efficient equilibrium, however.

Table 1 about here

The second weakest-link game (denoted *WL-RISK*, see panel [B] of Table 1) has not been studied before. It keeps the property of Pareto-ranked equilibria, but reinforces the attraction of the maximin-criterion as a selection device since any number greater than "1" can lead to zero payoffs. Therefore, *WL-RISK* provides a stress-test of the relative importance of payoff-dominance versus taking a secure action.

2.2. The four average-opinion games in detail

The first three average-opinion games shown in Table 2 are taken from van Huyck et al. (1991), and the fourth one from van Huyck et al. (1997). Game *AO-BASE* in panel [A] has the payoff-dominant equilibrium again in the upper-left corner where all decision makers choose

“7”, but the action maximizing the minimum payoff is to choose “3” (rather than “1” as in the weakest link games). Still, *AO-BASE* entails a tension between payoff-dominance and taking a secure action. In order to separate the importance of forces, van Huyck et al. (1991) have developed the coordination games shown in panels [B] and [C] of Table 2. By setting all payoffs outside the diagonal to zero, applying the maximin-criterion can no longer help in discriminating between the different equilibria in *AO-PAY*. This leaves payoff-dominance as the most likely selection criterion. In *AO-RISK* (see panel [C]), the equilibria along the diagonal are no longer Pareto-ranked. This means that payoff-dominance provides no guidance in this game, yet the maximin-criterion suggests choosing “4”.

Table 2 about here

The game *SEPARATRIX* (see panel [D]) is also known as continental-divide game. It has a more complex choice set and two symmetric strict equilibria: {3, …, 3}, and {12, …, 12}.[9] The interesting facet of this coordination game is that adaptive behavior in the repeated game (assuming either myopic best response or fictitious play) will lead to the Pareto dominated equilibrium of {3, …, 3} when the first-round median is “7” or lower, but to the payoff-dominant equilibrium of {12, …, 12} when the first-round median is “8” or higher.

3. Experimental design

We have set up two treatments in each of the six coordination games introduced above. In the “*Individuals*”-treatments we let five individuals interact in the respective game for 20

[9] In the design of van Huyck et al. (1997) where groups included 7 subjects, there is also an efficient asymmetric equilibrium with four subjects choosing 14 and three subjects choosing either 13 or 12. van Huyck et al. (1997) never observed coordination on such an asymmetric equilibrium.

periods, and this partner matching is common knowledge. In each period, each individual has to choose independently a number from the feasible interval.

The “*Teams*”-treatments are, in principle, identical to the corresponding “*Individuals*”-treatments, except that a group of decision-makers consists of five teams – instead of five individuals. In the following we use the term “group” to denote the entity of players that interacts with each other. The “group size” is always five in our experiment. The term “team” refers to three subjects who are requested to arrive at a joint team decision by agreeing on a single number to be chosen by all team members. They can communicate via an electronic chat (in which only revealing one’s identity or using abusive language is forbidden). The experimental instructions (available in Supplement A) do not specify how team members should arrive at a team decision. Each team member has to enter the team’s decision individually on his computer screen.[10] In the *Teams*-treatments the payoffs in the matrix are understood as a per-capita payoff for each team member. This approach is taken to keep the individual marginal incentives constant across the *Individuals*- and *Teams*-treatments.

The feedback given after each period is identical in the *Teams*- and *Individuals*-treatments. Each decision-maker is informed about the own payoff and about either the minimum number, or the median, depending upon the game. This means that we do not reveal the full distribution of chosen numbers within a group, but only the relevant order statistic.

Table 3 about here

[10] If different numbers were entered, team members could chat again and enter a decision once more. Only if the second attempt failed again the team received no payment in this period. Note that this happened only three times in all experiments (i.e., in 3 out of 3,900 cases where teams had to reach an agreement). In *WL-BASE*, one team could not reach an agreement in two out of 20 periods. In *WL-RISK*, one team could not reach an agreement in one period. For completeness, the instructions specified that if a team did not reach an agreement in a particular period, this team would be disregarded for determining the order-statistic. In the weakest-link games the minimum number submitted by the teams who reached an agreement is always unambiguous. In the average opinion games, the median may become a fractional number if only an even number of teams submitted a decision (such as when the valid submitted numbers were 2, 4, 5, 6, with a median of 4.5). In the latter case the median was randomly rounded up or down.

Table 3 summarizes our experimental design. In total, 825 subjects participated in the computerized experiment. We used zTree (Urs Fischbacher, 2007) for programming and ORSEE (Ben Greiner, 2004) for recruiting. The weakest-link games were run at the University of Cologne, and the average-opinion games at the University of Innsbruck. No subject was allowed to participate in more than one session. The average duration was 45 minutes in *Individuals*-sessions, respectively 65 minutes in *Teams*-sessions. The exchange rate of points (indicated in Tables 1 and 2) into Euro was always 200 points = 1€. The average performance-related earnings were 9€ per subject, plus a show-up fee of 2.5€.

4. Experimental Results

Table 4 presents an overview of the main data. In panel [A] it shows the average numbers chosen in the very first period. The first-period data are particularly interesting because these choices can not have been influenced by any history of the game. Therefore, the first-period data indicate "genuine" differences in coordination behavior between individuals and teams, irrespective of any differences due to learning.

Table 4 about here

Both in the first period as well as across all 20 periods (see panel [B] of Table 4) the average numbers of teams are always higher than those of individuals, and the differences are in most cases significant.[11] Only in game *AO-RISK*, the average numbers are practically the same for individuals and teams. Recall that *AO-RISK* is the only game, though, in which the

[11] Note that for testing we can use all first-period choices, i.e., we can take *all five* numbers from each single group, because first-period choices are independent. When examining the average data across all 20 periods, we treat each group (with five decision-makers) as *one* independent unit of observation. Table 3 shows the number of independent observations at the group-level. Except for *WL-BASE* it is always 6.

different equilibria are *not* Pareto-ranked. All other games involve Pareto-ranked equilibria, and in these games we find clear differences between individuals and teams.

Figures 1 to 4 about here

Figures 1 and 2 show the development of averages over single periods. In the five games where payoff-dominance applies, teams choose the higher numbers in each single period.[12] This statement is also clearly supported by Figures 3 and 4, which present the relative frequencies of choosing a particular number.[13] In each single game with payoff-dominance, the distribution of numbers is shifted to the right by team decision-making.

Turning from the chosen numbers to the actually resulting minimum, respectively median, number within groups, we see from panel [C] of Table 4 that teams generally succeed in coordinating on higher minimum or median numbers. As a consequence, teams have substantially and significantly higher payoffs than individuals, as can be seen in panel [D] of Table 4. Across all six games, teams earn on average about 20% more per capita than individuals. We summarize these findings in Table 4 in our first result:

Result 1. *Teams choose higher numbers, i.e., they target the more efficient equilibria rather than the more secure ones in all games where equilibria are Pareto-ranked. This yields significantly higher profits for teams. Only when payoff-dominance does not discriminate between the different equilibria do we find no differences between individuals and teams with respect to chosen numbers and profits.*

Table 5 about here

[12] While in the weakest-link games choices of individuals and teams tend to go down over time, in three of the average opinion games the average of the chosen numbers goes up, in particular in the early periods. In the game *AO-RISK* the average numbers are virtually constant over time and identical for individuals and teams.

[13] For referees' convenience, we show in Supplement B the distribution of chosen numbers in each single group and for each period separately.

The superiority of teams with respect to payoffs is also driven by a significantly smaller amount of miscoordination. Table 5 presents three different indicators for this statement. Miscoordination (in panel [A]) is measured as the average absolute deviation of each of the five chosen numbers from the actual minimum/median in a given group and period. This indicator is always larger for individuals than for teams, and again significant for all games with payoff-dominance. Panel [B] reports the relative frequency over all periods in which perfect coordination is achieved by all five decision makers choosing the same (not necessarily the most efficient) number. Except for *SEPARATRIX*, teams succeed in perfect coordination significantly more often than individuals in games with payoff-dominance. In *AO-RISK*, the relative frequency of perfect coordination does not differ between individuals and teams. The third indicator "adjustment" (see panel [C]) measures the absolute differences between a decision-maker's number in period t and the minimum/median in period t–1. Table 5 shows that there is always a higher level of adjustment activity in the *Individuals*-treatments than in the *Teams*-treatments, confirming once more that teams settle quicker for an equilibrium. This yields our next result:

Result 2. *Teams are more successful at avoiding miscoordination and settle into an equilibrium more quickly.*

5. Econometric analysis by using the experience weighted attraction learning model

In this section, we present an econometric analysis of learning in the six coordination games in order to explain in more detail why teams are much more successful in coordinating efficiently than individuals. We use the experience weighted attraction (EWA) learning model of Camerer and Ho (1999).[14] In this model players' strategies have attractions that reflect initial predispositions and are updated by taking into account past outcomes. In a nutshell, the EWA-model integrates reinforcement learning models and belief-based models (like fictitious play) into a single learning model. The following subsection offers a brief account of the EWA-model, which is then followed by a subsection presenting the estimation results and how learning differs between individuals and teams.

5.1. A brief account of EWA learning

We start with notation. For each player (either individual or team) there are *m* pure strategies (*m* = 14 in *SEPARATRIX*, *m* = 7 in all other games). Let s_i^j be player *i*'s strategy *j*, and $s_i(t)$, respectively $s_{-i}(t)$, the strategy of player *i*, respectively all other players' strategies, in period *t*. At time *t* the relevant order statistic is denoted by $z(t)$. Player *i*'s payoff of choosing strategy s_i^j in time *t* is $\pi_i(s_j^i, z(t))$.

For player *i* strategy *j* in period *t* has a numerical attraction $A_i^j(t)$, which determines the probability of choosing it by the following logistic function.

$$P_i^j(t+1) = \frac{e^{\lambda A_i^j(t)}}{\sum_{k=1}^{m} e^{\lambda A_i^k(t)}}. \qquad (1)$$

The parameter λ represents the response sensitivity for mapping attractions into choice probabilities. If $\lambda = 0$, strategies would be chosen randomly, $\lambda = \infty$ would imply best response. The attractions for each strategy are updated after each period according to the following equation:

$$A_i^j(t) = \frac{\phi \cdot N(t-1) \cdot A_i^j(t-1) + \{\delta + [1-\delta] I(s_i^j, s_i(t))\} \pi_i(s_j^i, z(t))}{N(t)}, \qquad (2)$$

[14] Ho, Camerer and Juin-Kuan Chong (2007) present a refinement of the original EWA-model, which they call self-tuning EWA. The latter model provides a one-parameter theory of learning. Ho et al. (2007) compare the estimation results of EWA (of Camerer and Ho, 1999) and self-tuning EWA, finding that for coordination games the EWA model has a slightly better fit (according to the Bayesian information criterion). This was the main reason for us to present the EWA-model instead of the self-tuning one here. In fact, we have also estimated the self-tuning EWA-model and found that both models yield very similar results.

where *N(t)* is a weight on the past attractions following the updating rule $N(t) = \phi(1-\kappa)N(t-1)+1$. The indicator function $I(x,y)$ is equal to zero if $x \neq y$ and one if $x = y$. Variables *N(t)* and $A_i^j(t)$ have initial values *N(0)* and $A_i^j(0)$, respectively, reflecting pregame experience. The parameter δ determines the weight put on foregone payoffs in the updating process. It places a positive weight on unchosen strategies only if $\delta > 0$. If $\delta = 1$ the attractions of all strategies (the one actually chosen and all others) are updated according to the payoffs these strategies have or would have generated, hence this covers fictitious play. The case of $\delta = 0$ captures pure reinforcement learning. Parameter ϕ discounts previous attractions. A lower ϕ reflects a higher decay of previous attractions due to forgetting or deliberate ignorance of old experience in case the environment changes. Parameter κ determines the discount rate of the experience weight $N(t)$.[15]

For estimating parameters λ, ϕ, κ, δ and $N(0)$ we determine initial attractions as follows. We assume, for each game and treatment, initial attractions equal to the expected payoff for each strategy, using the order statistic's frequencies observed in the first period. For the same game and treatment we assume that initial attractions are equal for all players. The likelihood function to estimate is then given by:

$$L(\lambda,\phi,\delta,k,N(0)) = \prod_{i=1}^{5}\left[\prod_{t=1}^{20} P_i^{s_i(t)}(t)\right], \tag{5}$$

[15] Note that Camerer and Ho (1999) formulate this slightly differently, albeit equivalently, in their paper.. They define $N(t) = \rho\, N(t-1)+1$. From the working-paper of the self-tuning EWA-model (Ho et al., 2001), it becomes clear that $\rho = \phi(1-\kappa)$, which we use here.

5.2. *EWA-estimates for individuals and teams*

In Table 6 we report the estimates for parameters λ, ϕ, δ, κ and $N(0)$ in the EWA learning model.[16] It is particularly noteworthy that in each single game, teams have a larger λ than individuals, and this difference is statistically significant in all games.[17] This means that the sensitivity of teams to attractions is always larger. Hence, if teams and individuals faced equal attractions, teams would be more likely to choose the strategy with the highest attraction.

Table 6 about here

Moreover, in each single game, we observe a larger δ for teams, and this difference is statistically significant in 4 games out of 6. This means that in the process of updating stragegies' attractions, teams take into account the hypothetical payoffs from unchosen strategies much more than individuals do. In other words, teams are more of the fictitious-play learning-type, whereas individuals are closer to a pure reinforcement learning-type. This difference between individuals and teams affects, of course, the dynamics of play since strategies with higher payoffs (even if not chosen) accumulate higher attractions, which are then chosen more likely by teams. As a consequence, team decisions are more heavily centered on higher numbers in all games with Pareto-ranked equilibria. This yields a larger degree of efficient coordination and ultimately higher payoffs for teams than individuals.

In both weakest-link games we find a significantly lower ϕ for teams, reflecting that they have a higher decay of previous attractions, meaning that the most recent play has a relatively stronger impact on the attractions. In other words, teams discard old experience more quickly.

[16] The parameters are determined by a single estimation using all data of one treatment rather than computing the averages of parameters for each single group as defined in (5).

[17] Note that aggregate data for *AO-RISK* (in Figure 2) look very similar for individuals and teams, but the estimations show a strong difference in λ between individuals and teams. The larger λ for teams is due to teams deviating less (and less often) from previous medians than individuals.

In the average-opinion games, there is no clear-cut pattern concerning the difference between individuals and teams with respect to ϕ. Similarly, the estimates for κ as a discount rate of the experience weight $N(t)$ do not point in the same direction in all games. Overall, the unambiguous differences in λ and δ are the most striking differences in learning between individuals and teams. These differences imply that settlement in an (efficient) equilibrium is quicker. The probability to play a strategy corresponding to the previous minimum, or median, is increasing in the parameters λ and δ, meaning that larger λ and δ make it more likely that decision-makers choose in period t the order statistic of period t–1. This yields less miscoordination and quicker settlement in equilibrium in the *Team*-treatments. We summarize the insights from the EWA-learning model as follows:

Result 3. *According to the experience weighted attraction learning model, teams have a higher sensitivity to the different strategies' attractions. Moreover, in the attraction updating process teams pay more attention to the payoffs of unchosen strategies. These facts imply a higher probability of playing more profitable strategies, leading ultimately to more efficient coordination when equilibria are Pareto-ranked.*

6. Relation to the literature on team-decision making

In recent years, behavioral differences between individuals and teams have attracted more and more attention in economics, because many economic decisions are made by teams, such as families, company boards, workgroups, management teams, committees, or central bank boards. In this section we relate our findings to this literature and highlight the contribution of our paper.

When putting the analysis of team decision making on his list of top ten open research questions, Camerer (2003) conjectured that team decisions might be closer to standard game theoretic predictions (assuming selfishness and rationality) than individual decisions. In fact, this conjecture has been confirmed for a variety of games.[18] For example, teams have been found to send and accept smaller transfers in the ultimatum game (Bornstein and Ilan Yaniv, 1998) and to be less generous in the dictator game (Wolfgang Luhan, Martin G. Kocher and Matthias Sutter, 2008).[19] Teams send or return smaller amounts in the trust game (James C. Cox, 2002, Tamar Kugler et al., 2007) and exit the centipede game at earlier stages (Bornstein, Kugler and Anthony Ziegelmeyer, 2004). They choose smaller numbers and converge quicker to the equilibrium in guessing games (Kocher and Sutter, 2005) and play more often strategically in signaling games (Cooper and John H. Kagel, 2005).

Contrary to these earlier studies, the coordination games studied in this paper involve the issue of selecting among multiple equilibria, a task which has not been examined with teams so far. Nevertheless, there is a close link between the existing literature and our findings of more efficient coordination with team decision-making. One way to organize the evidence from the various games (like ultimatum, dictator, trust, centipede, beauty-contest, or signaling games) is that team decisions are more driven by a concern for monetary payoffs than individual decisions. A recent paper by Charness, Luca Rigotti and Aldo Rustichini (2007b) has shed light on the reasons for this effect. They have found in a prisoner's dilemma game that the mere fact of becoming a group member lets individuals shift their decisions towards those that are more favorable, and profitable, for the group. Such a shift can explain our finding that team decisions in coordination games are more strongly driven by payoff-dominance considerations. In fact, we have been able to confirm the importance of payoff-dominance for the differences between individuals and teams by using the EWA learning model. We have found that teams are more sensitive in their decisions to the attractions of

[18] There is also evidence from non-interactive decision-making tasks that team decisions comply more often with standard notions of rationality, like using Bayesian updating (see Tilman Slembeck and Jean-Robert Tyran, 2004, in the context of the three-doors anomaly, or Charness, Edi Karni and Dan Levin, 2007a, for risky decision making) or applying logic to solve problems (such as the Wason selection task; see Boris Maciejovsky and David V. Budescu, 2007).

[19] The paper by Tim Cason and Vai-Lam Mui (1997) is often misinterpreted as showing that teams are more generous than individuals in a dictator game. However, Cason and Mui (1997) did not find that teams in general

different strategies and that they consider foregone payoffs (of unchosen strategies) more strongly when updating attractions. Since attractions are therefore linked to payoffs – with more profitable strategies getting higher attractions – it is clear that teams focus more on strategies with higher payoffs. This facilitates the coordination on more efficient equilibria. A larger sensitivity to attractions can also be interpreted as teams having a lower probability of choosing strategies with relatively low attractions (which they got because they were or would have been unprofitable in the past). As a consequence of this, teams are more steadfast in their decisions in the following sense. *Ceteris paribus*, teams are more likely than individuals to choose strategies with higher attractions in a given period t even if the performance of the particular strategy was not optimal in period t–1. In other words, individuals give up quicker in trying to reach a more efficient equilibrium when they have experienced miscoordination in the previous period.

In sum, our paper contributes to the literature on team decision-making in the following ways: (i) It fills the gap of analyzing behavior of teams in coordination games. (ii) It provides a thorough analysis of learning of teams in these games and compares it to learning of individuals.[20] (iii) It uses six different games, rather than one particular game, to provide a comprehensive assessment of the differences between individuals and teams.

7. Conclusion

In this paper we have shown that teams are persistently and remarkably better in achieving efficient outcomes in coordination games. This is particularly true in games where payoff-dominance can serve as an equilibrium selection device among several Pareto-ranked

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are more generous than individuals, but only reported more other-regarding team choices when team members differed in their individual dictator game choices.

[20] Ho et al. (2007) have applied the self-tuning EWA model to examine Kocher and Sutter's (2005) data on team decision data in a beauty-contest game. We are not aware of any other attempt to study how teams learn in

equilibria. Using the experience weighted attraction learning model of Camerer and Ho (1999) we have found that teams are much more sensitive to the attractions of different strategies. Since more profitable strategies get higher attractions, team decisions are more heavily influenced by monetary considerations than individual decisions. Furthermore, teams are steadfast in trying to achieve an efficient outcome, and they are much more successful in strictly best-responding (ex post) to what other teams do.

Our findings add a novel, and hitherto overlooked, dimension to the recently flourishing literature on how efficient outcomes can be reached in coordination games. Previous studies have identified several factors that facilitate successful and efficient coordination (among individuals). From an organizational point of view, the use of financial incentives (Brandts and Cooper, 2006a, Hamman et al., 2007), the opportunity of communication (Blume and Ortmann, 2007) or managed growth (Weber, 2006) may be considered the most important of these factors. We have determined team decision-making as another major factor. It is important to note that teams coordinate more efficiently in two large families of coordination games, i.e., in weakest-link games as well as average-opinion games, provided that equilibria are Pareto-ranked. Therefore, our findings can be considered a robust phenomenon of team decision-making in coordination games. They lend support to the almost universal practice of firms and organizations to set up work teams as a means to enhance efficient interactions inside an organization and even in networks between organizations.

comparison to individuals. Hence, our focus on team learning in coordination games can be considered another contribution to the literature on team decision-making.

References

Berninghaus, Siegfried and Ehrhart, Karl-Martin (1998). "Time Horizon and Equilibrium Selection in Tacit Coordination Games." *Journal of Economic Behavior and Organization* 37, 231-248.

Blume, Andreas and Ortmann, Andreas (2007). "The Effects of Costless Pre-Play Communication: Experimental Evidence from Games with Pareto-Ranked Equilibria." *Journal of Economic Theory* 132, 274-290.

Bornstein, Gary, Gneezy, Uri and Nagel, Rosemarie (2002). "The Effect of Intergroup Competition on Group Coordination: An Experimental Study." *Games and Economic Behavior* 41, 1-25.

Bornstein, Gary, Kugler, Tamar and Ziegelmeyer, Anthony (2004). "Individual and Group Decisions in the Centipede Game: Are Groups More 'Rational' Players?." *Journal of Experimental Social Psychology* 40, 599-605.

Bornstein, Gary and Yaniv, Ilan (1998). "Individual and Group Behaviour in the Ultimatum Game: Are Groups More 'Rational' Players?." *Experimental Economics* 1, 101-108.

Brandts, Jordi and Cooper, David J. (2006a). "A Change Would Do You Good …. An Experimental Study on How to Overcome Coordination Failure in Organizations." *American Economic Review* 96, 669-693.

Brandts, Jordi and Cooper, David J. (2006b). "Observability and Overcoming Coordination Failure in Organizations: An Experimental Study." *Experimental Economics* 9, 407-423.

Cachon, Gerard P. and Camerer, Colin F. (1996). "Loss-Avoidance and Forward Induction in Experimental Coordination Games." *Quarterly Journal of Economics* 111, 165-194.

Camerer, Colin F. (2003). *Behavioral Game Theory*. Princeton: Princeton University Press.

Camerer, Colin F. and Ho, Teck H. (1999). "Experience-Weighted Attraction Learning in Normal Form Games." *Econometrica* 67, 827-874.

Camerer, Colin F. and Knez, Marc J. (1997). "Coordination in Organizations: A Game Theoretic Perspective." In: Zur Shapira (ed.). *Organizational Decision Making*. Cambridge: Cambridge University Press, 158-188.

Cason, Tim and Mui, Vai-Lam (1997). "A Laboratory Study of Group Polarization in the Team Dictator Game." *Economic Journal* 107, 1465-1483.

Charness, Gary (2000). "Self-Serving Cheap Talk: A Test of Aumann's Conjecture." *Games and Economic Behavior* 33, 177-194.

Charness, Gary and Jackson, Matthew O. (2007). "Group Play in Games and the Role of Consent in Network Formation." *Journal of Economic Theory* 136, 417-445.

Charness, Gary and Jackson, Matthew O. (2008). "The Role of Responsibility in Strategic Risk-Taking." *Journal of Economic Behavior and Organization*, forthcoming.

Charness, Gary, Karni, Edi and Levin, Dan (2007a). "Individual and Group Decision Making Under Risk: An Experimental Study of Bayesian Updating and Violations of First-Order Stochastic Dominance." *Journal of Risk and Uncertainty* 35, 129-148.

Charness, Gary, Rigotti, Luca and Rustichini, Aldo (2007b). "Individual Behavior and Group Membership." *American Economic Review* 97, 1340-1352.

Cooper, David J. and Kagel, John H. (2005). "Are Two Heads Better Than One? Team versus Individual Play in Signaling Games." *American Economic Review* 95, 477-509.

Cooper, Russell (1999). *Coordination in Games: Complementarities and Macroeconomics*. Cambridge UK: Cambridge University Press.

Cooper, Russell, DeJong, Douglas V., Forsythe, Robert and Ross, Thomas W. (1990). "Selection Criteria in Coordination Games: Some Experimental Results." *American Economic Review* 80, 218-233.

Cooper, Russell, DeJong, Douglas V., Forsythe, Robert and Ross, Thomas W. (1992). "Communication in Coordination Games." *Quarterly Journal of Economics* 107, 739-771.

Cox, James C. (2002). “Trust, Reciprocity, and Other-Regarding Preferences: Groups vs. Individuals and Males vs. Females.” In: Zwick, Rami, Rapoport, Amnon (eds.)., *Advances in Experimental Business Research*, 331-350, Dordrecht: Kluwer Academic Publishers.

Crawford, Vincent P. (1991). “An “Evolutionary” Interpretation of Van Huyck, Battalio, and Beil’s Experimental Results on Coordination.” *Games and Economic Behavior* 3, 25-59.

Crawford, Vincent P. (1995). “Adaptive Dynamics in Coordination Games.” *Econometrica* 63, 103-143.

Crawford, Vincent P. and Broseta, Bruno (1998). “What Price Coordination? The Efficiency-Enhancing Effect of Auctioning the Right to Play.” *American Economic Review* 88, 198-225.

Crawford, Vincent P., Gneezy, Uri and Rottenstreich, Yuval (2008). “The Power of Focal Points is Limited: Even Minute Payoff Asymmetry May Yield Large Coordination Failures.” *American Economic Review*, 98, 1443-1458.

Cropper, Steve, Ebers, Mark, Huxham, Chris, and Smith Ring, Peter (2008). *The Oxford Handbook of Inter-Organizational Relations*. Oxford UK: Oxford University Press.

Devetag, Giovanna (2003). “Coordination and Information in Critical Mass Games: An Experimental Study.” *Experimental Economics* 6, 53-73.

Devetag, Giovanna and Ortmann, Andreas (2007). “When and Why? A Critical Survey on Coordination Failure in the Laboratory.” *Experimental Economics* 10, 331-344.

Duffy, John and Feltovich, Nick (2002). “Do Actions Speak Louder than Words? An Experimental Comparison of Observation and Cheap Talk.” *Games and Economic Behavior* 39, 1-27.

Duffy, John and Feltovich, Nick (2006). “Words, Deeds and Lies: Strategic Behavior in Games with Multiple Signals.” *Review of Economic Studies* 73, 669-688.

Fischbacher, Urs (2007). “z-Tree: Zurich Toolbox for Ready-Made Economic Experiments.” *Experimental Economics* 10, 171-178.

Friedman, James W. (ed.) (1994) *Problems of Coordination in Economic Activity*. Boston M.A.: Kluwer.

Goeree, Jacob and Holt, Charles A. (2005). “An Experimental Study of Costly Coordination.” *Games and Economic Behavior* 51, 349-364.

Greiner, Ben (2004). “An Online Recruiting System for Economic Experiments.” In: Kurt Kremer, Volker Macho (eds.). Forschung und wissenschaftliches Rechnen 2003. GWDG Bericht 63, Goettingen: Ges. Für Wiss. Datenverarbeitung, 79-93.

Hamman, John, Rick, Scott and Weber, Roberto A. (2007). “Solving Coordination Failure with “All-or-None” Group-level Incentives.” *Experimental Economics* 10, 285-303.

Harsanyi, John and Selten, Reinhard (1988). *A General Theory of Equilibrium Selection in Games*. Cambridge, M.A., MIT Press.

Heath, Chip, and Staudenmeyer, Nancy (2000) “Coordination Neglect: How Lay Theories of Organizing Complicate Coordination in Organizations.” *Research in Organizational Behavior* 22, 153-191.

Heinemann, Frank, Nagel, Rosemarie and Ockenfels, Peter (2004). “The Theory of Global Games on Test: Experimental Analysis of Coordination Games with Public and Private Information.” *Econometrica* 72, 1583-1599.

Ho, Teck H., Camerer, Colin F. and Chong, Juin-Kuan (2001). “Economic Value of EWA Lite: A Functional Theory of Learning in Games.” California Institute of Technology. Social Science Working Paper 1122.

Ho, Teck H., Camerer, Colin F. and Chong, Juin-Kuan (2007). “Self-tuning experience weighted attraction learning in games.” *Journal of Economic Theory* 133, 177-198.

Katzenbach, Jon R. and Smith, Douglas K. (1993) The *Wisdom of Teams – Creating the High-Performance Organization*. Boston M.A.: Harvard Business School Press.

Knez, Marc J. and Simester, Duncan (2001). "Firm-Wide Incentives and Mutual Monitoring at Continental Airlines." *Journal of Labor Economics* 19, 743-772.

Kocher, Martin G. and Sutter, Matthias (2005). "The Decision Maker Matters: Individual Versus Group Behaviour in Experimental Beauty-Contest Games." *Economic Journal* 115, 200-223.

Kugler, Tamar, Bornstein, Gary, Kocher, Martin and Sutter, Matthias (2007). "Trust Between Individuals and Groups: Groups are Less Trusting than Individuals but Just as Trustworthy." *Journal of Economic Psychology* 28, 646-657.

Luhan, Wolfgang, Kocher, Martin and Sutter, Matthias (2008). "Group Polarization in the Team Dictator Game Reconsidered." *Experimental Economics*, forthcoming.

Maciejovsky, Boris and Budescu, David V. (2007). "Collective Induction Without Cooperation? Learning and Knowledge Transfer in Cooperative Groups and Competitive Auctions." *Journal of Personality and Social Psychology* 92, 854-870.

Rydval, Ondrej and Ortmann, Andreas (2005). "Loss Avoidance as Selection Principle: Evidence from Simple Stag-Hunt Games." *Economics Letters* 88, 101-107.

Schelling, Thomas C. (1980) *The Strategy of Conflict*. Boston M.A.: Harvard University Press.

Schmidt, David, Shupp, Robert, Walker, James M. and Ostrom, Elinor (2003). "Playing Safe in Coordination Games: the Roles of Risk Dominance, Payoff Dominance, and History of Play." *Games and Economic Behavior* 42, 281-299.

Slembeck, Tilman and Tyran, Jean-Robert (2004). "Do Institutions Promote Rationality? An Experimental Study of the Three-Door Anomaly." *Journal of Economic Behavior and Organization* 54, 337-350.

Van Huyck, John B., Battalio, Richard C. and Beil, Richard O. (1990). "Tacit Coordination Games, Strategic Uncertainty, and Coordination Failure." *American Economic Review* 80, 234-248.

Van Huyck, John B., Battalio, Richard C. and Beil, Richard O. (1991). "Strategic Uncertainty, Equilibrium Selection, and Coordination Failure in Average Opinion Games." *Quarterly Journal of Economics* 106, 885-910.

Van Huyck, John B., Battalio, Richard C. and Beil, Richard O. (1993). "Asset Markets as an Equilibrium Selection Mechanism: Coordination Failure, Game Form Auctions, and Tacit Collusion." *Games and Economic Behavior* 5, 485-504.

Van Huyck, John B., Battalio, Richard C. and Beil, Richard O. (1997). "Adaptive Behavior and Coordination Failure." *Journal of Economic Behavior and Organization* 32, 483-502.

Weber, Roberto A. (2006). "Managing Growth to Achieve Efficient Coordination in Large Groups." *American Economic Review* 96, 114-126.

Tables and Figures

Table 1: Payoffs in the weakest-link games

[A] *WL-BASE*	Smallest number chosen in the group						
Own number	**7**	**6**	**5**	**4**	**3**	**2**	**1**
7	130	110	90	70	50	30	10
6		120	100	80	60	40	20
5			110	90	70	50	30
4				100	80	60	40
3					90	70	50
2						80	60
1							70

[B] *WL-RISK*	Smallest number chosen in the group						
Own number	**7**	**6**	**5**	**4**	**3**	**2**	**1**
7	130	0	0	0	0	0	0
6		120	0	0	0	0	0
5			110	0	0	0	0
4				100	0	0	0
3					90	0	0
2						80	0
1							70

Table 2: Payoffs in the average-opinion games

[A] ***AO-BASE***	Median number chosen in the group						
Own number	**7**	**6**	**5**	**4**	**3**	**2**	**1**
7	130	115	90	55	10	-45	-110
6	125	120	105	80	45	0	-55
5	110	115	110	95	70	35	-10
4	85	100	105	100	85	60	25
3	50	75	90	95	90	75	50
2	5	40	65	80	85	80	65
1	-50	-5	30	55	70	75	70

[B] ***AO-PAY***	Median number chosen in the group						
Own number	**7**	**6**	**5**	**4**	**3**	**2**	**1**
7	130	0	0	0	0	0	0
6	0	120	0	0	0	0	0
5	0	0	110	0	0	0	0
4	0	0	0	100	0	0	0
3	0	0	0	0	90	0	0
2	0	0	0	0	0	80	0
1	0	0	0	0	0	0	70

Table 2 - continued

[C] ***AO-RISK***	Median number chosen in the group						
Own number	**7**	**6**	**5**	**4**	**3**	**2**	**1**
7	70	65	50	25	-10	-55	-110
6	65	70	65	50	25	-10	-55
5	50	65	70	65	50	25	-10
4	25	50	65	70	65	50	25
3	-10	25	50	65	70	65	50
2	-55	-10	25	50	65	70	65
1	-110	-55	-10	25	50	65	70

[D] ***SEPARATRIX***	Median number chosen in the group													
Own number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1	45	49	52	55	56	55	46	-59	-88	-105	-117	-127	-135	-142
2	48	53	58	62	65	66	61	-27	-52	-67	-77	-86	-92	-98
3	48	54	60	66	70	74	72	1	-20	-32	-41	-48	-53	-58
4	43	51	58	65	71	77	80	26	8	-2	-9	-14	-19	-22
5	35	44	52	60	69	77	83	46	32	25	19	15	12	10
6	23	33	42	52	62	72	82	62	53	47	43	41	39	38
7	7	18	28	40	51	64	78	75	69	66	64	63	62	62
8	-13	-1	11	23	37	51	69	83	81	80	80	80	81	82
9	-37	-24	-11	3	18	35	57	88	89	91	92	94	96	98
10	-65	-51	-37	-21	-4	15	40	89	94	98	101	104	107	110
11	-97	-82	-66	-49	-31	-9	20	85	94	100	105	110	114	119
12	-133	-117	-100	-82	-61	-37	-5	78	91	99	106	112	118	123
13	-173	-156	-137	-118	-96	-69	-33	67	83	94	103	110	117	123
14	-217	-198	-179	-158	-134	-105	-65	52	72	85	95	104	112	120

Table 3: Experimental design

Coordination game	Number of participants		Number of groups/observations		Choices (sym. Equilibria)	
	Individuals	*Teams*	*Individuals*	*Teams*	Payoff-dominant	Maximin
WL-BASE (Tab. 1 [A])	90	135	18	9	7	1
WL-RISK (Tab. 1 [B])	30	90	6	6	7	1
AO-BASE (Tab. 2 [A])	30	90	6	6	7	3
AO-PAY (Tab. 2 [B])	30	90	6	6	7	-
AO-RISK (Tab. 2 [C])	30	90	6	6	-	4
SEPARATRIX (Tab. 2 [D])	30	90	6	6	12	3

Note that “groups” refers to a unit of five decision makers, either five individuals or five teams. Teams always consist of three subjects who can communicate via an electronic chat.

Table 4: Main results

	[A] Average numbers in 1st period			[B] Average numbers overall		
Coordination game	*Individuals*		*Teams*	*Individuals*		*Teams*
WL-BASE (Tab. 1 [A])	5.98	**	6.53	4.56	*	6.09
WL-RISK (Tab. 1 [B])	5.37	***	6.37	1.97		3.70
AO-BASE (Tab. 2 [A])	5.67		6.17	6.57	**	6.94
AO-PAY (Tab. 2 [B])	5.33	***	6.43	6.04	**	6.95
AO-RISK (Tab. 2 [C])	4.43		4.40	4.07		4.03
SEPARATRIX (Tab. 2 [D])	7.90	***	11.03	9.80	**	12.63
	[C] Average Minima / Medians			**[D]** Average payoffs		
	Individuals		*Teams*	*Individuals*		*Teams*
WL-BASE (Tab. 1 [A])	3.91	**	5.79	92.6	**	114.9
WL-RISK (Tab. 1 [B])	1.30		3.42	53.05	***	85.03
AO-BASE (Tab. 2 [A])	6.63		6.97	124.8	**	129.3
AO-PAY (Tab. 2 [B])	5.99	**	6.98	103.3	**	127.1
AO-RISK (Tab. 2 [C])	4.00		4.00	68.5		69.6
SEPARATRIX (Tab. 2 [D])	9.85	**	12.77	93.2	***	114.2

**** (**) [*]* *significant difference between individuals and teams at the 1% (5%) [10%] level (Mann-Whitney U-test)*
All numbers chosen in the first period are used for testing (panel [A]), i.e., *all five* numbers from each single group. Note that all first-period choices are independent. When examining the average data across all 20 periods (panels [B]-[D]), we treat each group (with five decision-makers) as *one* independent unit of observation.

Table 5: Coordination and adjustment

	[A] Miscoordination			**[B]** Perfect coordination			**[C]** Adjustment		
Coordination game	*Indiv.*		*Teams*	*Indiv.*		*Teams*	*Indiv.*		*Teams*
WL-BASE	0.65	**	0.30	0.41	*	0.69	0.60	*	0.29
WL-RISK	0.39	*	0.29	0.42	**	0.77	0.53	**	0.21
AO-BASE	0.14	***	0.06	0.75	**	0.89	0.09	**	0.03
AO-PAY	0.25	**	0.03	0.61	**	0.92	0.34	*	0.02
AO-RISK	0.12		0.04	0.75		0.91	0.10		0.01
SEPARATRIX	0.84	***	0.51	0.04		0.04	0.98	***	0.56

[A] Miscoordination is defined as the average of the absolute difference between a decision-maker's number and the minimum/median in the same period.

[B] Perfect coordination is defined as the fraction of periods where all five decision-makers choose the same number.

[C] Adjustment is defined as average of the absolute difference between a decision-maker's own number and the minimum/median in the previous period.

**** (**) [*] significant difference between individuals (Indiv.) and teams at the 1% (5%) [10%] level (Mann-Whitney U-test)*

Table 6: Parameter estimates of EWA learning model

Game	Parameter	Teams	Individuals	Game	Parameter	Teams	Individuals
WL-BASE	λ *	13.545	11.560	*WL-RISK*	λ ***	8.529	1.518
		(1.046)	(0.511)			(0.574)	(0.201)
	ϕ ***	0.582	0.743		ϕ ***	0.548	0.814
		(0.042)	(0.022)			(0.067)	(0.038)
	δ ***	0.766	0.677		δ	0.481	0.445
		(0.029)	(0.018)			(0.057)	(0.073)
	κ	0.000	0.000		κ ***	0.000	1.000
		(0.000)	(0.000)			(0.000)	(0.000)
	N(0) **	4.537	1.747		*N(0)* ***	3.259	0.000
		(1.245)	(0.257)			(0.948)	(0.000)
AO-BASE	λ ***	14.680	4.691	*AO-PAY*	λ ***	3.144	1.515
		(2.721)	(0.821)			(0.460)	(0.239)
	ϕ	0.730	0.583		ϕ *	0.669	0.812
		(0.090)	(0.058)			(0.078)	(0.031)
	δ ***	0.941	0.697		δ	0.912	0.268
		(0.019)	(0.055)			(0.516)	(0.067)
	κ	1.000	1.000		κ *	0.507	0.851
		(0.000)	(0.002)			(0.166)	(0.104)
	N(0)	0.000	0.395		*N(0)*	3.996	5.589
		(0.000)	(0.733)			(1.699)	(1.061)
AO-RISK	λ *	13.565	8.243	*SEPARA-*	λ ***	5.702	3.892
		(2.952)	(1.178)	*TRIX*		(0.600)	(0.362)
	ϕ	0.803	0.832		ϕ **	0.708	0.595
		(0.066)	(0.071)			(0.033)	(0.041)
	δ ***	0.906	0.129		δ ***	0.848	0.705
		(0.047)	(0.124)			(0.019)	(0.025)
	κ ***	1.000	0.080		κ	1.000	1.000
		(0.001)	(0.065)			(0.000)	(0.000)
	N(0)	3.580	0.658		*N(0)*	0.000	0.498
		(1.838)	(0.550)			(0.000)	(0.337)

**** (**) [*]* *significant difference between teams and individuals at the 1% (5%) [10%] level.*

Figures in brackets indicate standard errors

Figures

Figure 1: Average numbers in the weakest-link games

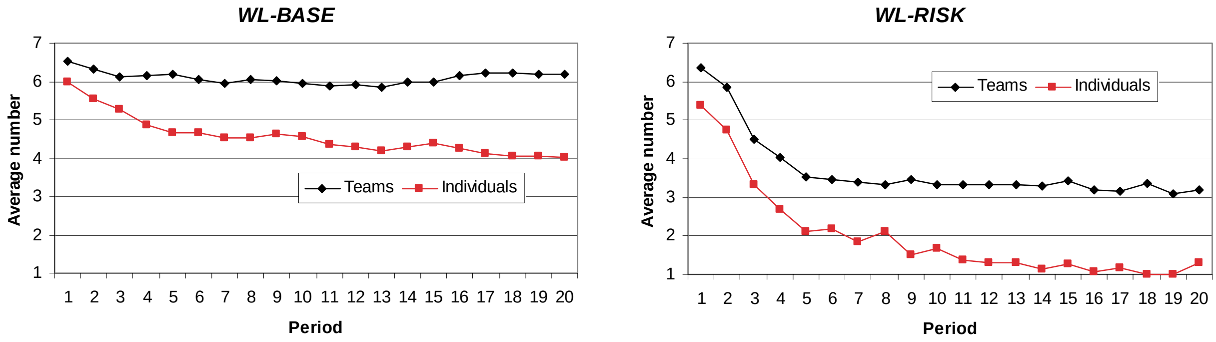


Figure 2: Average numbers in the average opinion games

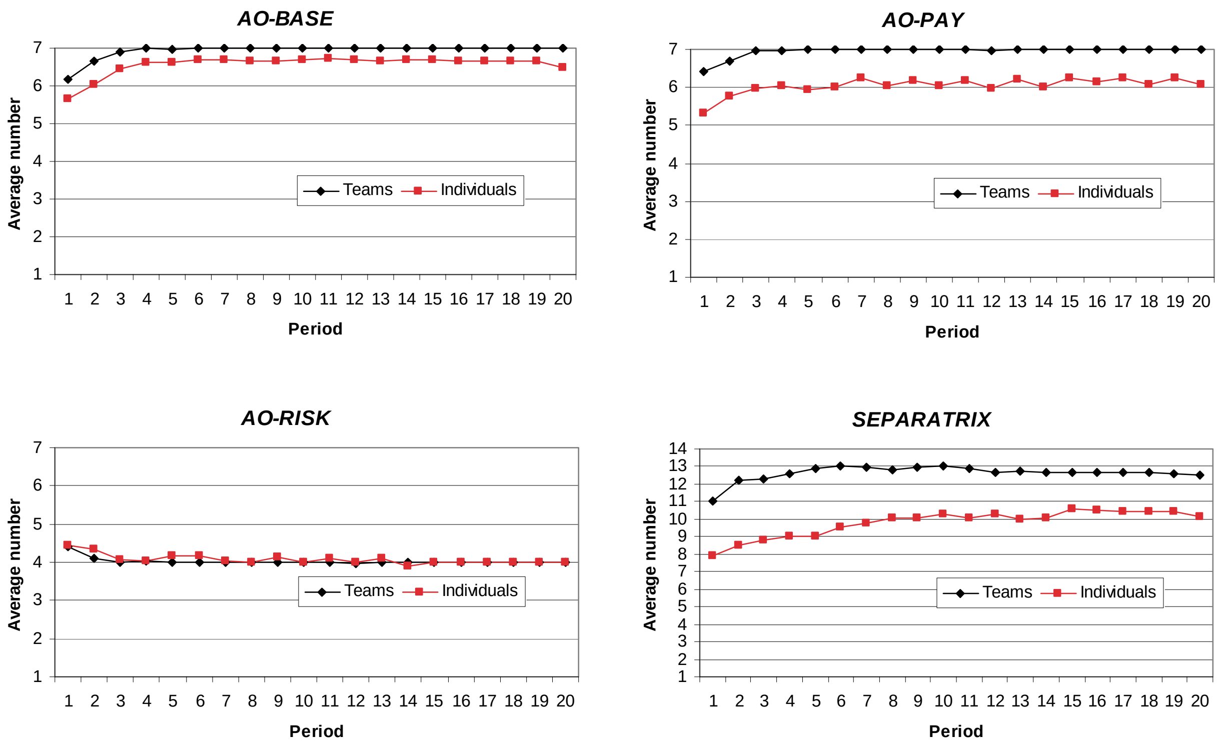


Figure 3: Relative frequencies of chosen numbers over all periods in weakest-link games

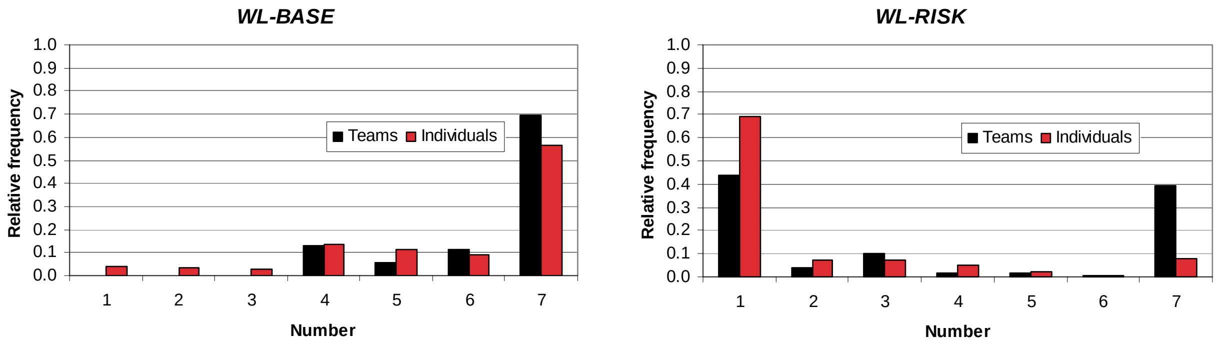
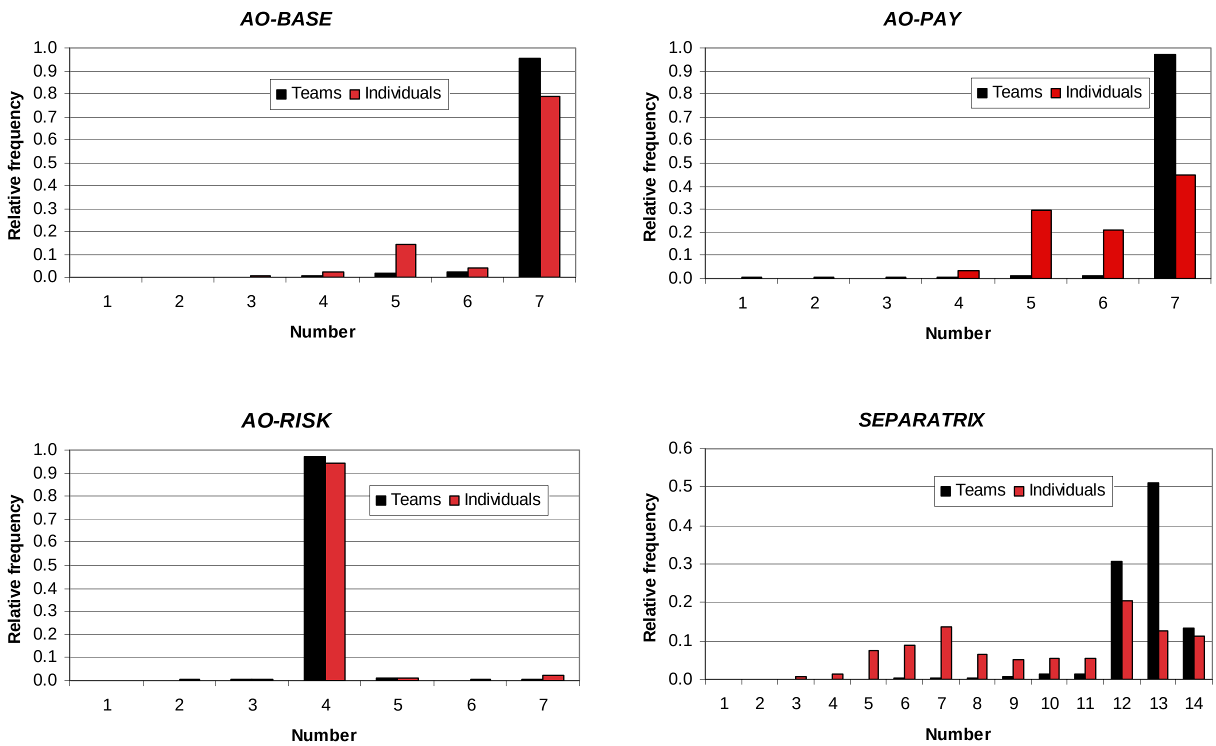


Figure 4: Relative frequencies of chosen numbers over all periods in average-opinion games



Supplementary material (not necessarily intended for publication)

Supplement A) Experimental instructions

We provide a translation (from German) of the instructions for game WL-BASE in the teams-treatment. The instructions for all other games and treatments were analogous. The complete set of instructions is available upon request.

Welcome to the experiment. Please do not talk to other participants until the experiment is completely over. In case you have questions, please raise your hand and an experimenter will assist you.

Number of periods and decision-making units

- This experiment has **20 periods**.
- There will be **units of 15 participants each**. You will only interact with members of the unit to which you are assigned throughout the whole experiment. Neither during nor after the experiment will you be informed of the identities of other members in your unit.

Teams

- Within each unit there will be **Teams** of **3 subjects** each. That means that each unit will have **5 teams**. Teams will stay together for the entire experiment.
- Members of a given team will have to agree on a **single decision for the whole team**. To do so, members can exchange messages through an instant messaging system at the bottom of their screens. As soon as you press "Return" after having written a message, it will be visible on the two other members' screens. You are allowed to send any message you like, except for those revealing your identity and except for using abusive language. If a team has agreed on a joint decision, each member has to enter this decision on his/her screen. In case the three entries are not identical, a team can go back to use the instant messaging system to agree on a joint decision. Then team members can enter the team's decision a second time. Note that a team that does not manage to enter a joint decision at that stage will not get any payoff for the respective period. If one team within a unit fails to enter a joint decision of all three members, then this team will not be considered in the determination of the outcome for the other teams.

Sequence of actions within a period

- **Choosing a number**

Each team has to choose a single **number** from the set {1, 2, 3, 4, 5, 6, 7}. Teams have to decide independently of other teams. After all teams have entered their number, you be informed about the smallest number chosen by any team in your unit (including your own team).

- **Period payoff**

Your payoff (in Talers) depends on your own number (i.e., the number of your team) and the smallest number chosen by any team within your unit. The **payoffs per member** of a team are given in the following table.

Payoff table (per team member)

Your number	Smallest number in unit						
	7	**6**	**5**	**4**	**3**	**2**	**1**
7	130	110	90	70	50	30	10
6		120	100	80	60	40	20
5			110	90	70	50	30
4				100	80	60	40
3					90	70	50
2						80	60
1							70

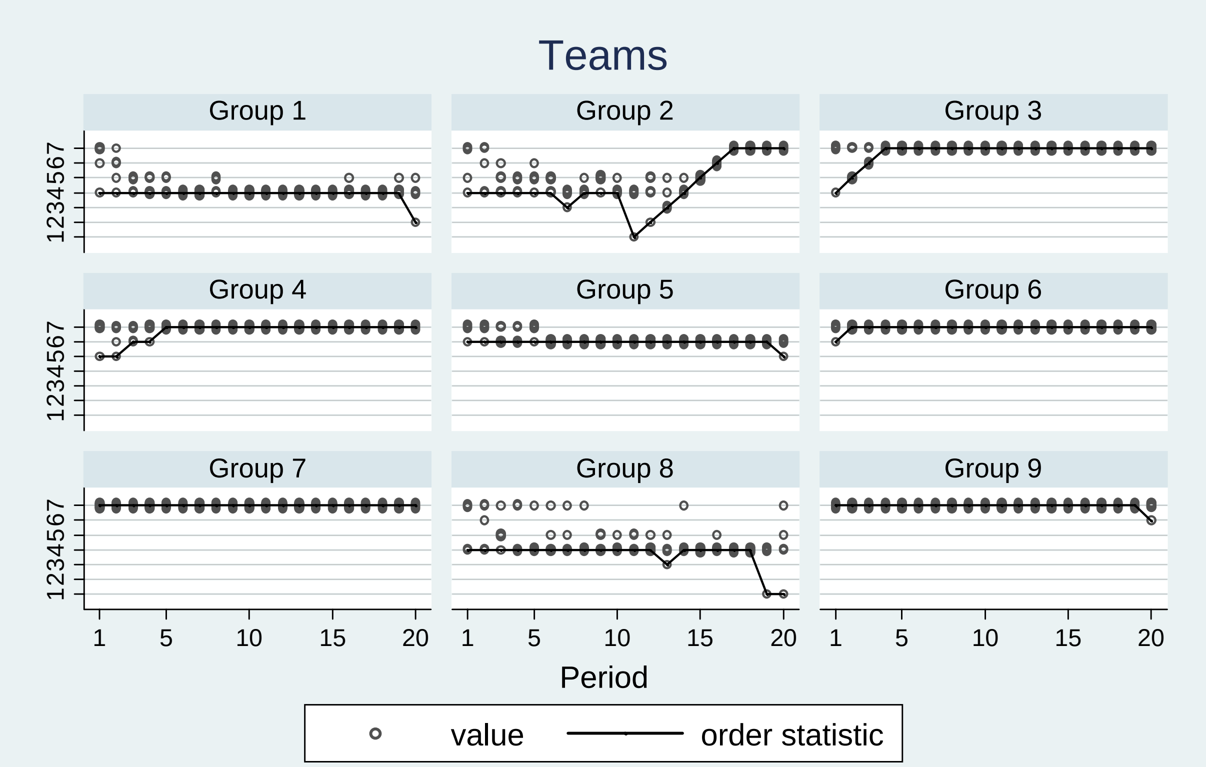
Total earnings

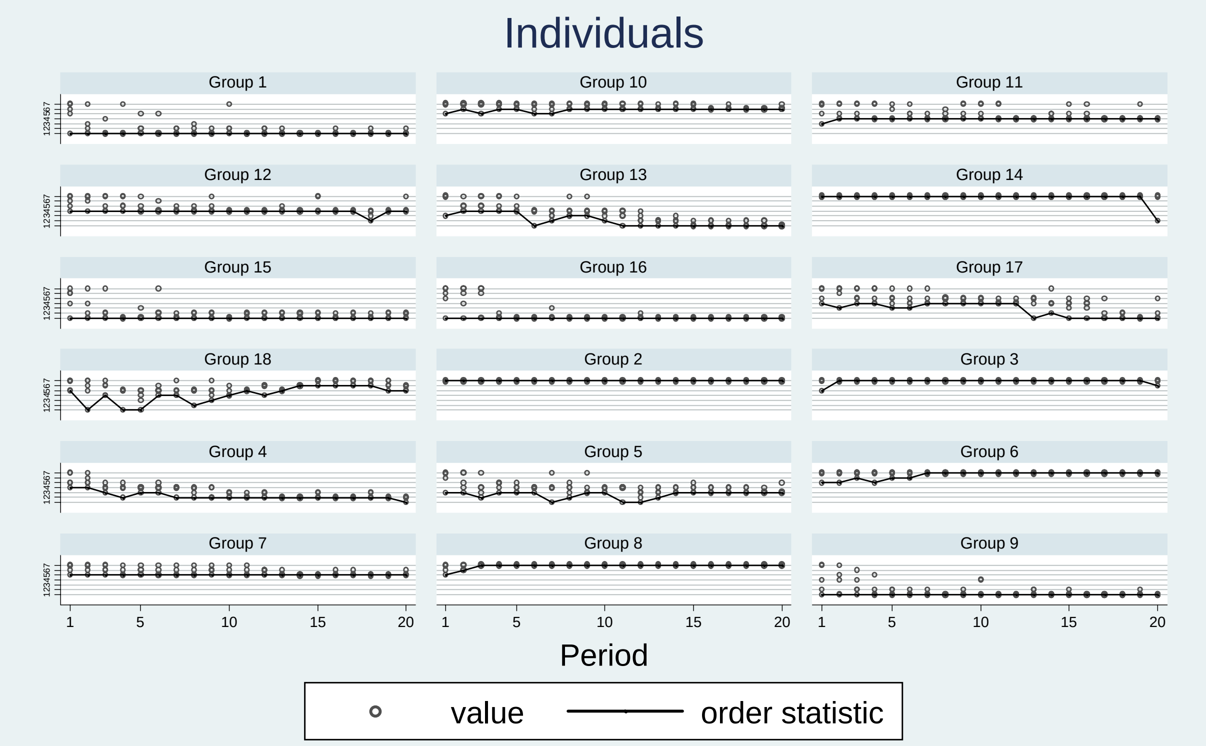
- The earnings of each period are accumulated and exchanged at the end of the experiment as follows: **200 Taler = 1€.** Each participant will receive his total earnings privately and confidentially. In addition to your earnings from the experiment, you will receive a **show-up fee of 2.50€**.

Supplement B) Raw data

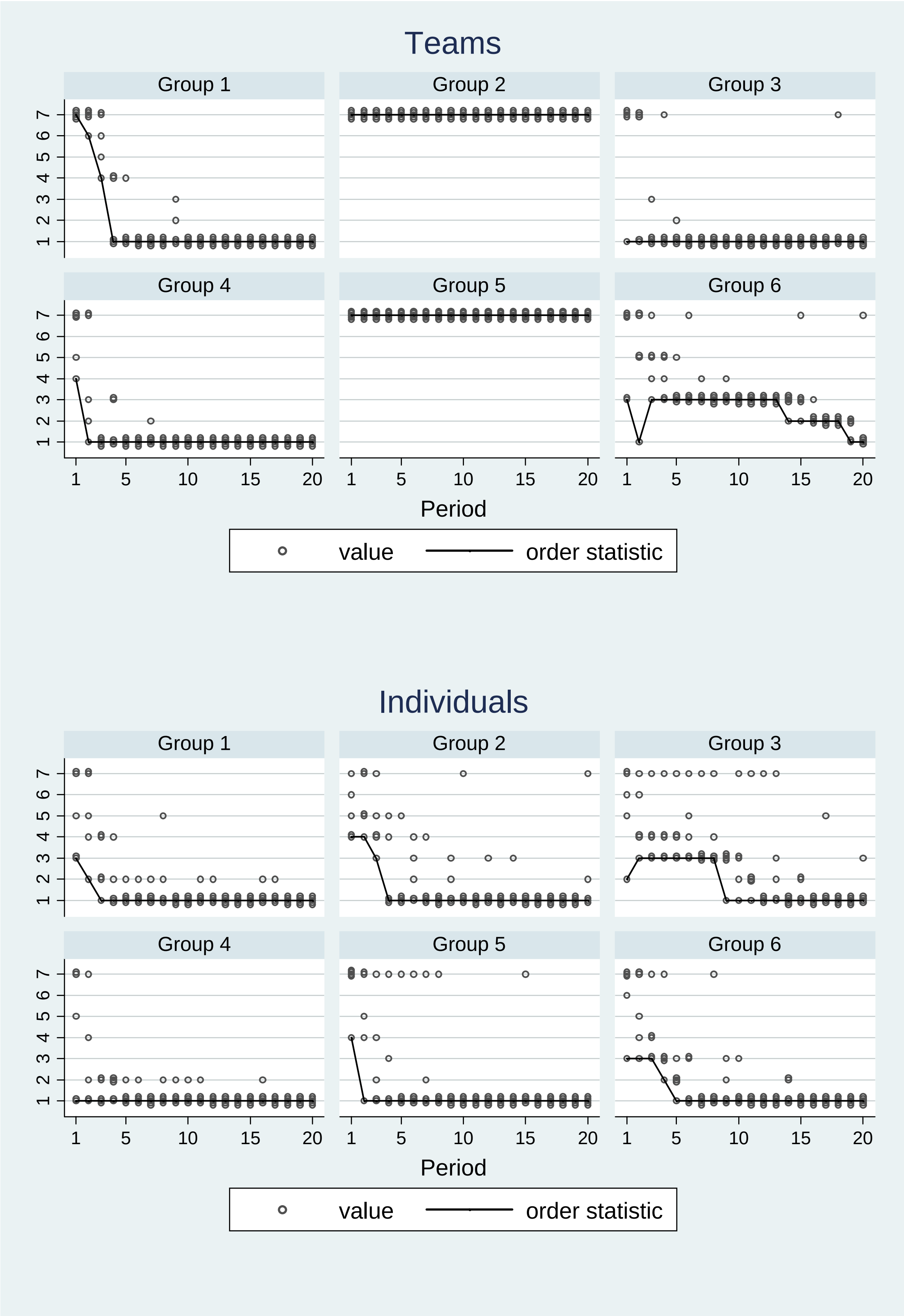
Multiple entries of a given number are indicated by jittering

WL-BASE



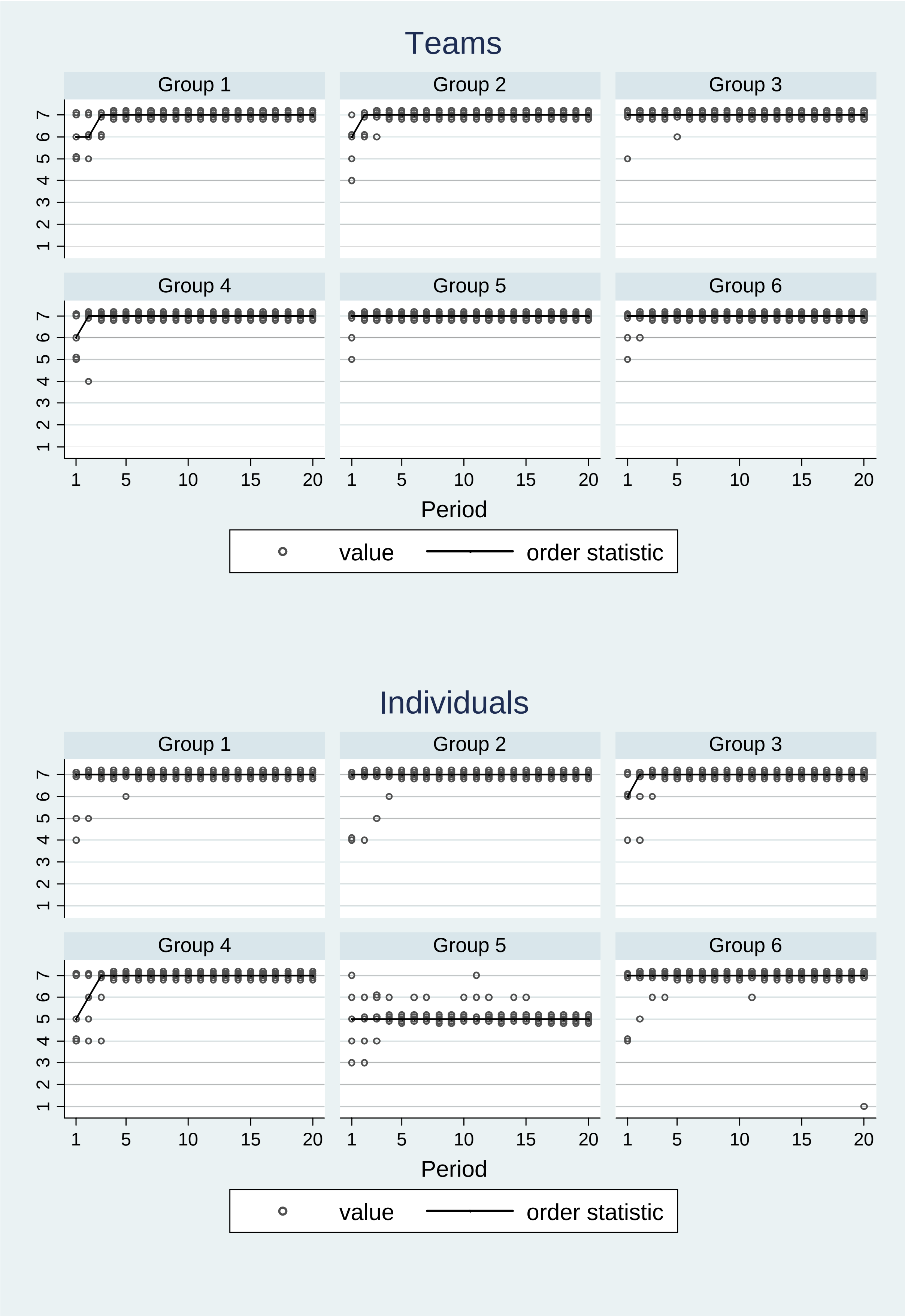


WL-RISK

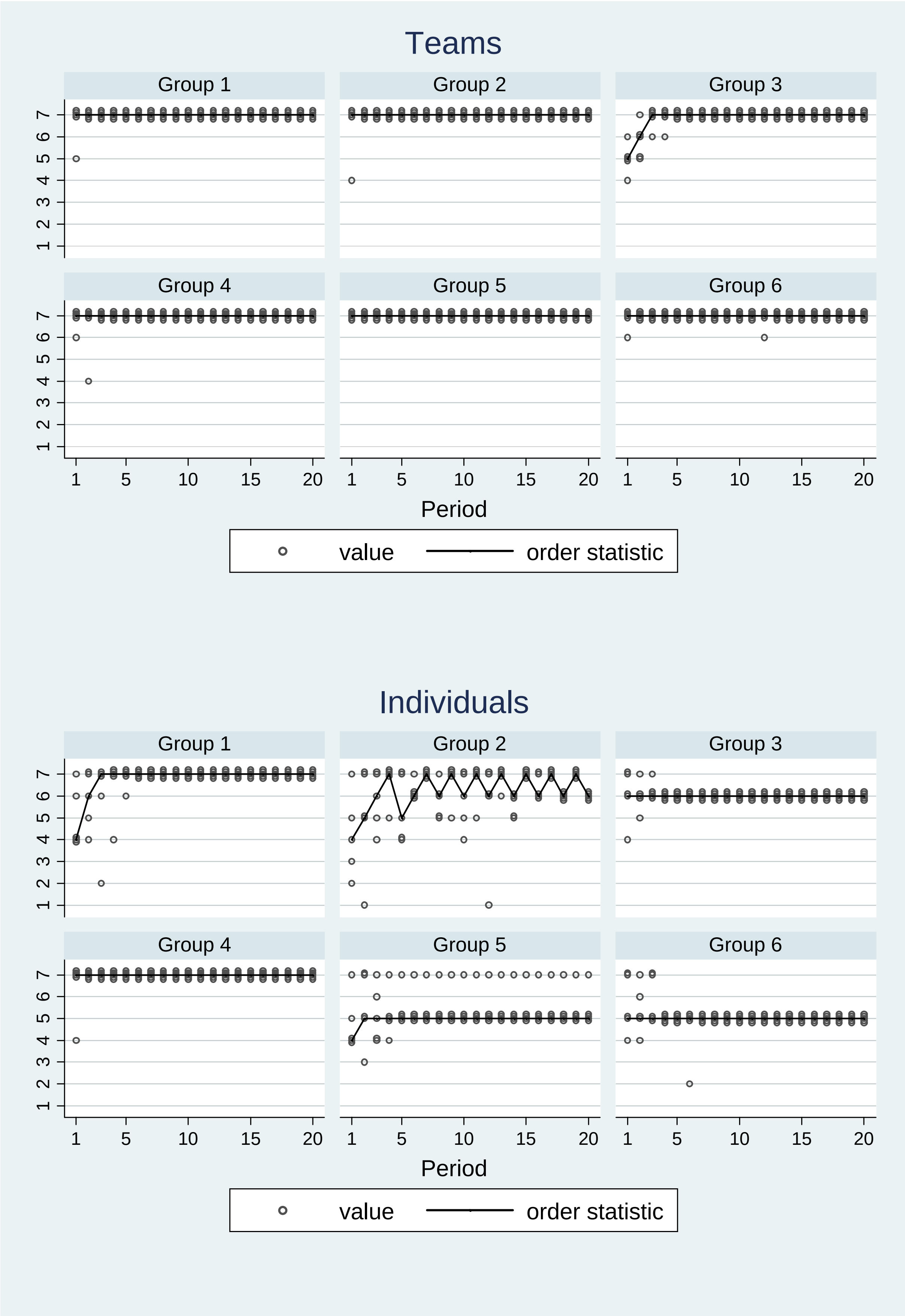


Teams
Group 1
Group 2
Group 3
Group 4
Group 5
Group 6
1 2 3 4 5 6 7
1 5 10 15 20
Period
value
order statistic
Individuals
Group 1
Group 2
Group 3
Group 4
Group 5
Group 6
1 2 3 4 5 6 7
1 5 10 15 20
Period
value
order statistic

AO-BASE


Teams
Group 1
Group 2
Group 3
Group 4
Group 5
Group 6
1 2 3 4 5 6 7
1 5 10 15 20
Period
value
order statistic
Individuals
Group 1
Group 2
Group 3
Group 4
Group 5
Group 6
1 2 3 4 5 6 7
1 5 10 15 20
Period
value
order statistic

AO-PAY


Teams
Group 1
Group 2
Group 3
Group 4
Group 5
Group 6
1 2 3 4 5 6 7
1 5 10 15 20
Period
value
order statistic
Individuals
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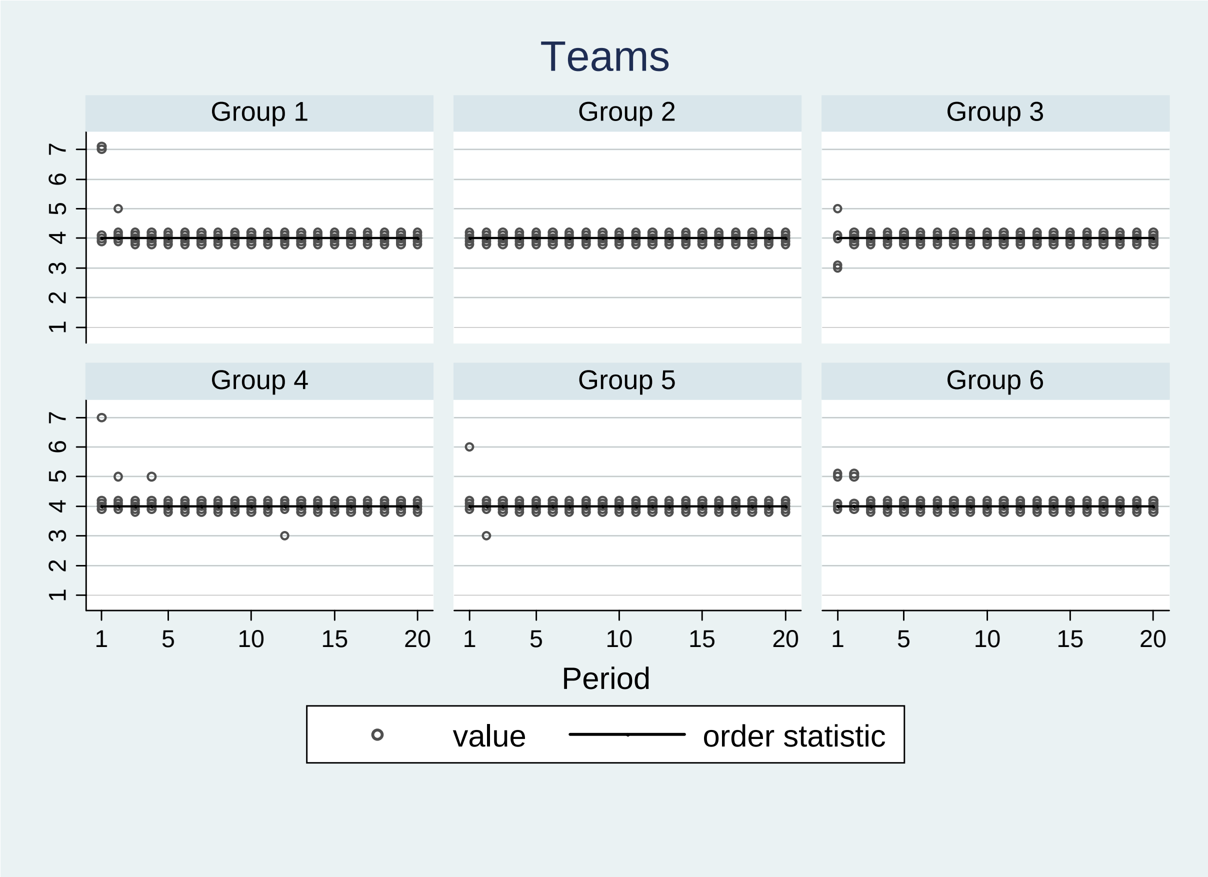
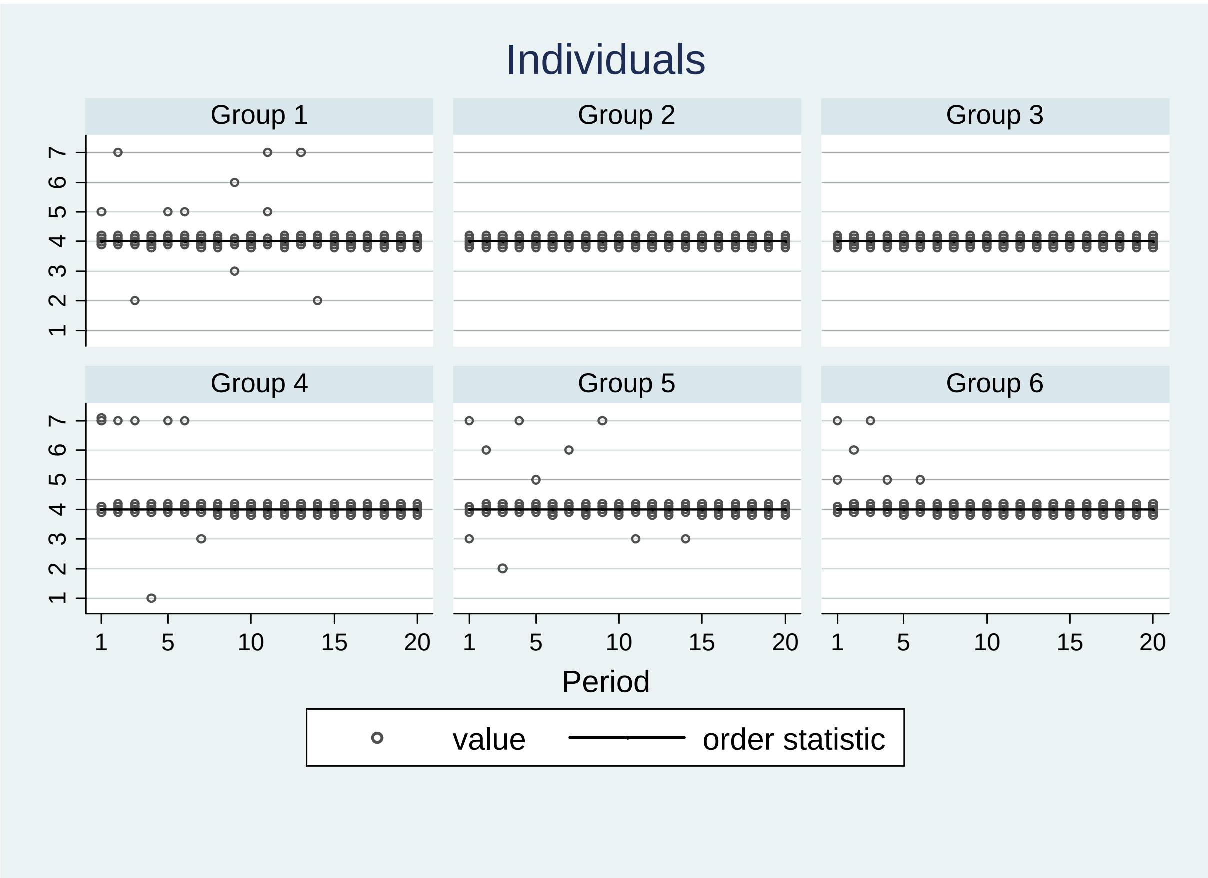
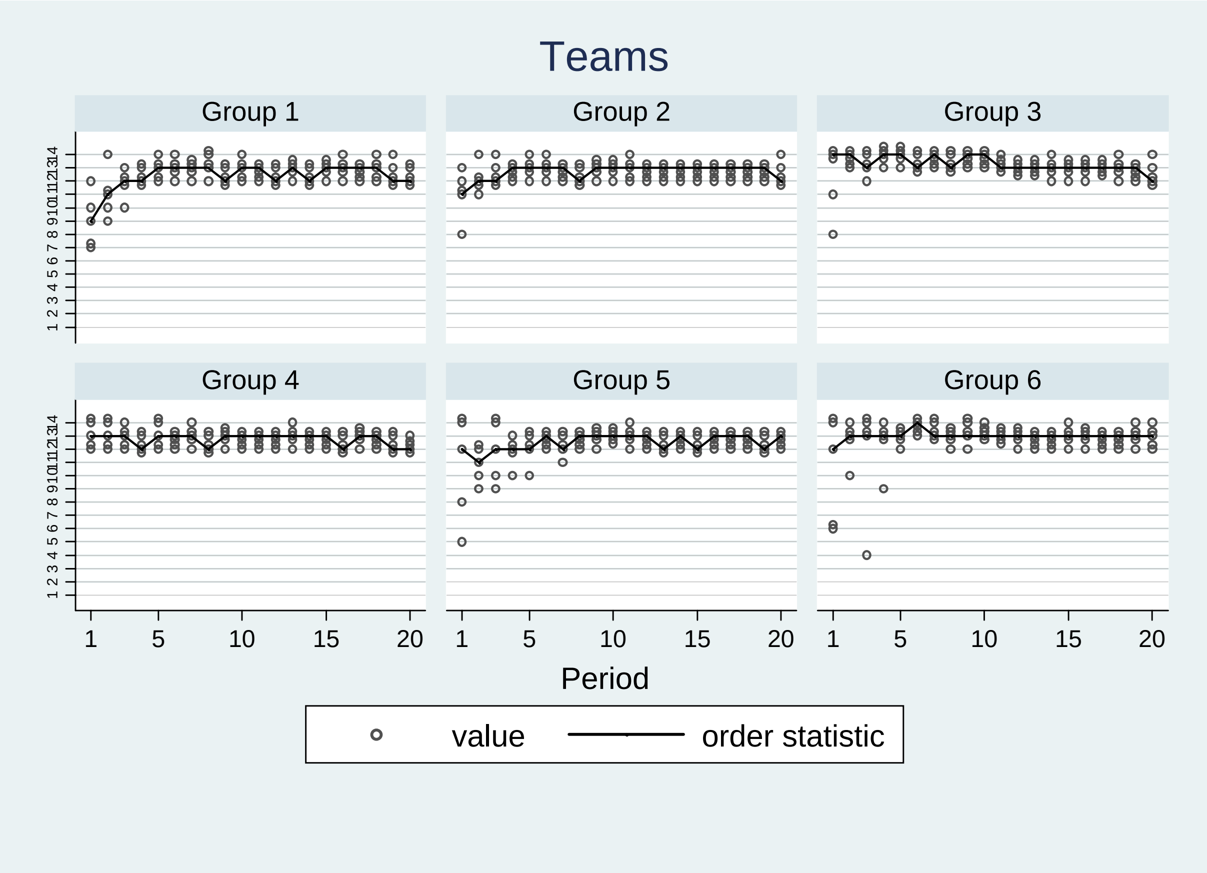
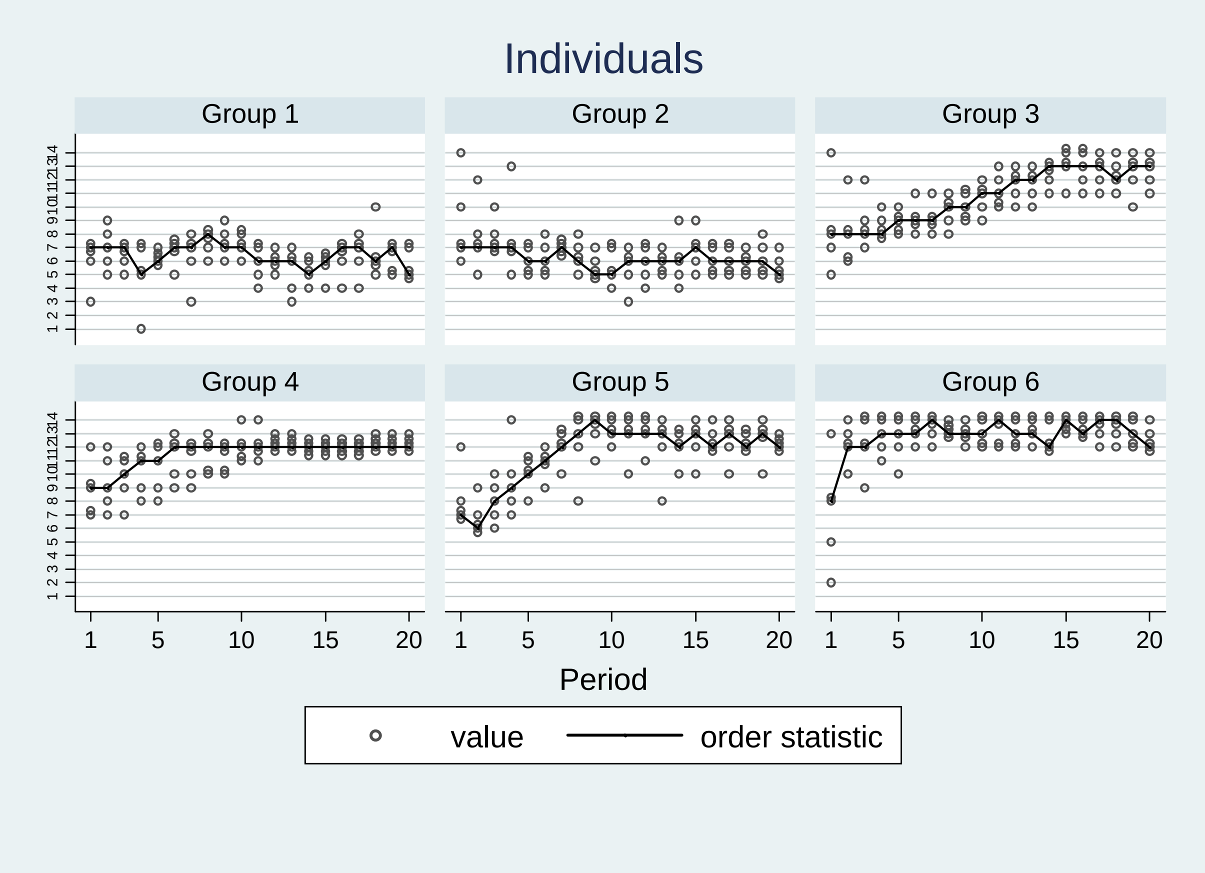
Group 2
Group 3
Group 4
Group 5
Group 6
1 2 3 4 5 6 7
1 5 10 15 20
Period
value
order statistic


Teams
Group 1
Group 2
Group 3
Group 4
Group 5
Group 6
1 2 3 4 5 6 7
1 5 10 15 20
Period
value
order statistic


Individuals
Group 1
Group 2
Group 3
Group 4
Group 5
Group 6
1 2 3 4 5 6 7
1 5 10 15 20
Period
value
order statistic



Teams
Group 1
Group 2
Group 3
Group 4
Group 5
Group 6
1 2 3 4 5 6 7 8 9 10 11 12 13 14
1 5 10 15 20
Period
value
order statistic



Individuals
Group 1
Group 2
Group 3
Group 4
Group 5
Group 6
1 2 3 4 5 6 7 8 9 10 11 12 13 14
1 5 10 15 20
Period
value
order statistic